NASA PM Challenge – 2007

Lessons Learned

from 737 & 787

Jet Liner Programs

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BOEING COMMERCIAL AIRPLANES

737
Most Produced Commercial Jet in History

Over 6,000 737s produced

- ■ **Significant changes over the last decade**
  - ➢ **Higher quality aircraft**
  - ➢ **Produced at a faster rate**
  - ➢ **Use less resources**
  - ➢ **Lower cost**

- ■ **Cultural shift from the legacy approach of requirements and production to a lean approach that strives for product commonality and producability**
  - ➢ **Approximately 60% of all the new 737s are common to each other which is a significant driver in reduction of costs and improvement of quality**
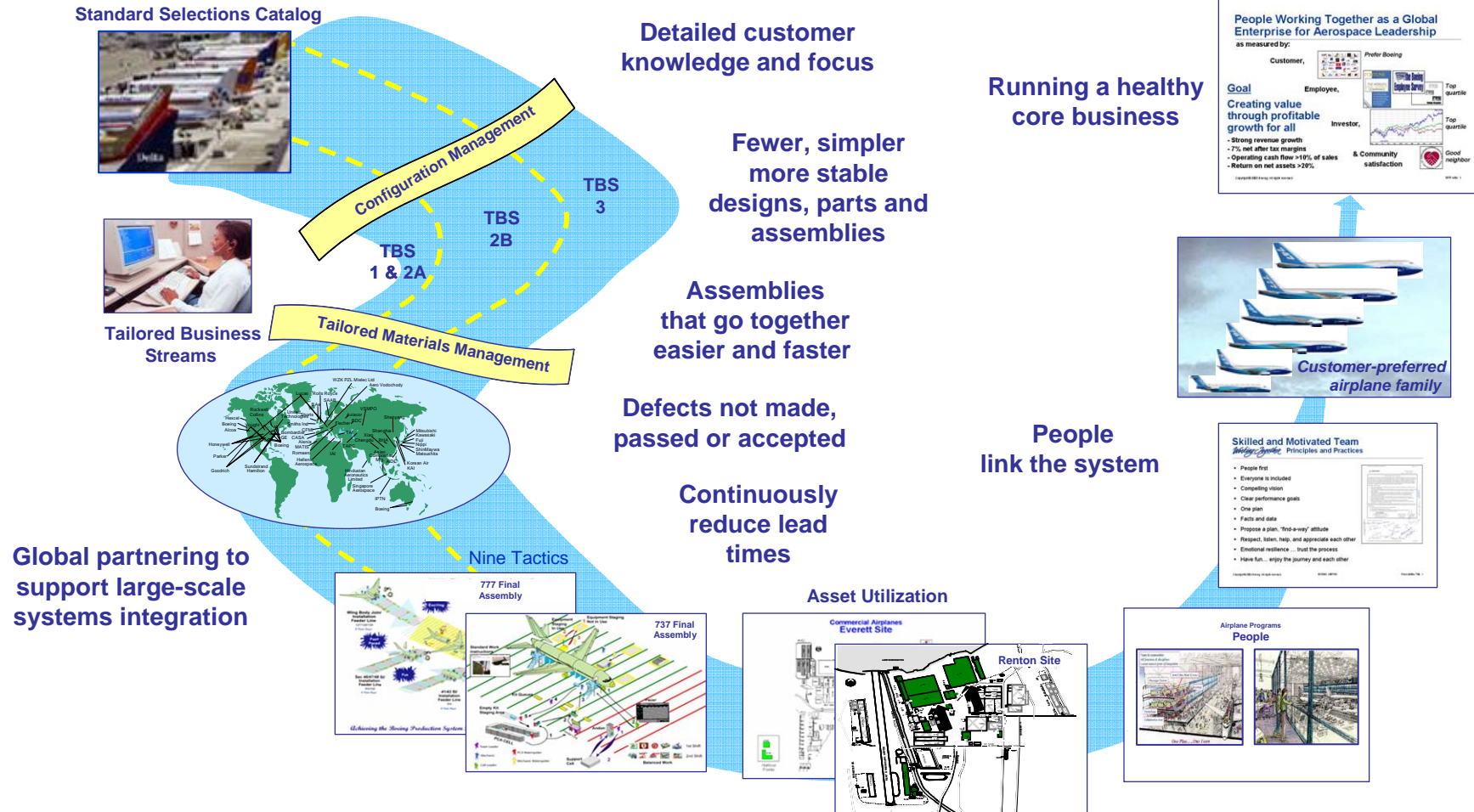 - ➢ **This cultural change starts at the top and flows down to the entire team**

- **Created a top level Production System Roadmap to Success**

- **Focus on "Value Stream Performance"**

- **In depth trade studies of what to perform in house and what to subcontract out**

- **Push integration as far ahead of final assembly as possible**
  - **Driven by understanding that higher quality can be obtained with integration occurring at the subcontractors prior to final aircraft assembly**

  - **Program level metrics and tools used to lead and monitor those trades studies**

737 - Boeing Production System

Standard Selections Catalog

Detailed customer knowledge and focus

Running a healthy core business

Configuration Management

Fewer, simpler more stable designs, parts and assemblies

TBS 3

TBS 2B

TBS 1 & 2A

Tailored Business Streams

Tailored Materials Management

Assemblies that go together easier and faster

Customer-preferred airplane family

Defects not made, passed or accepted

People link the system

Continuously reduce lead times

Global partnering to support large-scale systems integration

Nine Tactics

777 Final Assembly

737 Final Assembly

Asset Utilization

Renton Site

- **Each plane moved from integration station to integration station via crane moves (8000 crane lifts per month)**

- **Inventory based on "safe" overstock "just in case"**

- **Little pre-integration prior to final assembly**

- **Engineering team physically separated from production line so problem resolution required engineers to go to the production line across campus**

- **Then production started to ramp up to meet demand, but production methods were not changed**

- **Today the 737 assembly is a rolling line moving the aircraft from station to station**
  - ➤ **Pushed the pre-assembly back to the subcontractors to minimize the final assembly and maximize quality**
  - ➤ **Minimized the crane moves which now are down to only three per aircraft**
  - ➤ **Just in time inventory control so each day the inventory that is needed for that day is staged along the rolling line**
  - ➤ **Designers and factory floor assemblers are co located to solve problems when the engineering staff were moved into the factory and can look out their office windows to see the production line**
  - ➤ **Innovation solution to assembly are used like the chair loader designed and delivered by a farmer modeled after a hay loader**
  - ➤ **Minimize variability of parts and assemblies and focus on commonality**

737 - Summary

- **737 has traveled an incredible journey from the old ways of doing business to the new ways and it has been a true success**

- **It starts with a vision at the top and flows to all teams**

- **It was a holistic approach to solving problems and improving everything on the program**

- **Lessons learned on the 737 program were critical to the creation of the 787**

- **737 sets a very high standard of best commercial practices in the aerospace industry**

Maybe some of these lessons learned can be of value to the Constellation team

- Must design in commonality as a basic feature, engineers will strive for unique solution rather then common ones

- Must have champion driving commonality at the top who is the defender of the key principles for commonality

- Use small co-located teams to set the requirements and vision and then do not let the larger teams easily compromise those requirements and vision

- Focus on modular and reconfigurable designs

- Define and track metrics that focus on commonality

- Set tough goals and drive the team to meet them

- Use lots of independent review teams

- **787 set a short flow target to assemble the total aircraft at the final factory**
  - Driven by facility footprint and through put needs for production rates
  - Drove the emphasis to preassembly to occur prior to final assembly
  - Drove how subcontracts are defined and what work is done prior to shipment from the subs

- **Minimum lead time for configuration changes**
  - Manage updates to baseline as block updates rather then incremental continuous changes
  - Family of aircraft variants can benefit from block updates

■ **Use a trade study model for all trade studies that includes all variables including life cycle costs to ensure everyone allows for life cycle cost when they make design decisions (787 terms this Net Present Value Trade)**

➢ **Trade model allows for range of variables and tell you what are the real drivers**

➢ **Value everything, do not just use weighting factors**

➢ **Separate out recurring vs non recurring cost so you can see the impact of the commonality over program life cycle**

■**Control Variability including flowing this down to subcontractors and suppliers**

➢**Conducted workflow analysis to find and manage variability**

➢**Lay out vehicle family plan for variations but focus on driving commonality and only allow variations within the family based on need, not desire of the teams that own each variation within the family**

➢**Each design team must justify variability against the common baseline, so variability can occur but the default is commonality**

➢**Create a firm kill board for review and approval of unique variability and have that board control flow of money for variations**

■ **Define TPMs that drive and monitor commonality**

➢ **Establish TPMs for variability and treat them as key TPMs within the program management team**

➢ **TPMs for turnaround flow (time from a problem identification to fix completed) are important and can drive design trades**

➢ **Monitor and manage using the TPMs at the program manager level down to the implementation team level**

➢ **Think through the selection of TPMs to ensure they provide the valuable insights needed by the teams**

■ **One typical top level metric and goal setting was hours to install the interiors package**

➢ **Based on overall timeline analysis for installation and checkout**

➢ **Was not set as a percent improvement over previous programs but rather a top down derived goal**

➢ **Resulted in a focus on interfaces that had to be simple to install and allow for reconfigurations to meet specific customer variances**

➢ **Weight is an important metrics but just saving weight is not by itself a justification for unique designs the drive up life cycle costs**

■ **Select a limited list of choices for connectors, fasteners, tools, etc that can be used by the designers and manufacturing**

➤ **Force these as the default and push for the teams to show how they can use that set, not why they can not**

➤ **Variation can be considered but must be approved by the kill board based on total life cycle costs not just local design considerations**

➤ **Tools for installation and checkout on the line are limited to predefined set of options to minimize complex and costly custom tools or support equipment**

787 Program Commonality Insights Summary

- **Commonality is important to reduce total life cycle costs**

- **Driving commonality across the program is hard because it requires trading local optimization against program level commonality**

- **Need a vision and champion at the top that drives commonality and has the power to enforce that vision**

- **It is a culture, not a requirement, that makes it happen**

- **Use a holistic approach to commonality across design, manufacturing, integration, and operations**

Overly optimized local design is the bane of commonality

737 & 787 Lessons Learned Summary

- **Changing the paradigm starts with a vision at the top and flows to all teams**

- **737 and 787 both used a holistic approach to solving problems and improving everything on the program cutting across design, manufacturing, integration, and operations**

- **Driving commonality across the program is hard because it requires trading local optimization against program level commonality**

- **Need a champion at the top that drives fundamental changes and has the power to enforce that vision**

It is a culture, not a requirement, that makes it happen